REMARKS

Claims 1-4, 6-13, 15-17, 19 and 20 are pending in this application. Claims 1, 2, 4, 6, 12, 13 and 15 have been amended herein. Claims 5, 14 and 18 are cancelled, without prejudice. Claim 20 has been added. Claims 3, 7-11, 16, 17 and 19 remain unchanged.

Claims 1-19 stand rejected under 35 USC §103(a) as being obvious and therefore unpatentable over Borowiec et al. U.S. 5,830,420 or WO 97/19199.

In response, claims 1 and 6 have been amended to recite that the slag is oxidized at a temperature from "about 700°C to below about 900°C." Support for this amendment can be found in claims 2 and 15. By amending claims 1 and 6 in this manner, the amended claims clearly do not overlap with the teachings of Borowiec '420 and '199.

As discussed in the Background section of the present application (particularly at page 3, line 13 and further on), it is known to beneficiate ilmenite by subjecting it to oxidation and reduction. In the examples of GB1,225,826, ilmenite ore is oxidized at 870°C and reduction is also carried out at 870°C, i.e., at temperatures falling within the range of the present invention. The oxidized and reduced ilmenite is more amenable to acid leaching to upgrade the ilmenite. However, as set out at page 4, line 11, and further on in the specification, there are major differences between ilmenite ore and titania slag. For example, it is stated (page 5, lines 17-21) that pseudobrookite and amorphous glassy phases are characteristic of titania slag and generally do not occur in ilmenite ores. It is believed that the presence of pseudobrookite and the glassy phases in titania slag may be a reason why processes for beneficiating ilmenite ore are not applicable to the beneficiation of titania slag.

The Background section of the present application also discusses Borowiec '420 in detail (page 7, line 11 and further) by referring to PCT/CA96/00767, which is the application number of Borowiec WO '199 cited by the examiner. Borowiec relates to the oxidation and reduction of titania slag as is the case with the present invention. The process described in Borowiec has as its basis an oxidation roast followed by a reduction roast. The slag is first sized in the range 75-850μm and is then oxidized at a temperature of at least about 950°C, but preferably between 1000 and 1100°C, for at least 20 minutes. After the oxidation, the slag is reduced at a

temperature of at least about 700°C, but preferably between 800 and 850°C, for at least 30 minutes. The roasted titania slag is then leached under pressure in excess of atmospheric pressure and at a temperature of at least 125°C to remove the impurities present in the slag.

Borowiec stresses the differences between the treatment of ilmenite and titania slag, e.g. at col. 2, lines 52 to 63 of Borowiec '420, it is stated that the processes aimed at upgrading ilmenite ores are not applicable to the upgrading of titania slag. Borowiec '420 also specifically refers to GB 1,225,826 (col. 5, lines 25-35) stating that it relates to the upgrading of ilmenite ores by oxidation and reduction generically similar to the Borowiec upgrading of slag but under conditions of temperature and retention time that are inadequate for slags. Furthermore, in example 12 of Borowiec '420, it is illustrated that the process of GB1,225,826, relating to the treatment of ilmenite, is not suitable when applied to titania slag. Negligible removal of impurities are achieved when the process of GB 1,225,826 is applied to slag, that is by oxidizing the slag with air at 850°C for 2 hours and then reducing it with smelter gas at 850°C for 5 minutes, and thereafter leaching the resulting product with a hydrochloric acid solution under reflux conditions. Even if the process is modified by carrying out the oxidation at 900°C for 1 hour and the reduction at 900°C for 30 minutes (as set out in example 13 of Borowiec '420), very poor results are achieved.

Borowiec '420 (col. 6, line 6-19) teaches that the titania slag requires a pre-treatment within an unexpected window of process conditions (including oxidation at temperature of at least about 950°C) to render it suitable for acid leaching. That patent describes much harsher oxidation, reduction and acid leaching steps for slag than the conditions for ilmenite as disclosed in the related process of GB1,225,826.

Most surprisingly, it has now been found that if titania slag is oxidized at a lower temperature (from about 700°C to about 900°C) than that described in Borowiec, under the correct conditions to form a stabilized anatase phase, and the slag is thereafter reduced and further treated, the slag can be suitably upgraded. In some embodiments of the invention, it is not necessary to carry out the leaching at above atmospheric pressure. Leaching at a pressure above atmospheric pressure is required in the process of Borowiec. It will be appreciated that even if leaching at above atmospheric pressure may not be necessary for the successful beneficiation of

titania slag according to the invention, the process will also function if acid leaching is carried out at above atmospheric pressure.

Borowiec '420 teaches that during that process, the iron cations tend to concentrate around pores formed in the slag particles that will render them more accessible to leaching. It has been found that if the oxidation step is carried out at lower temperatures, as disclosed for the present invention, the iron in the slag particles surprisingly migrates to the rims of the slag particles. It has been found that such slag particles undergo rapid reduction roasting and that such slag particles are more amenable to acid leaching, which allows leaching to be conducted at atmospheric pressure.

In the light of the above, it is accordingly clear that Borowiec teaches away from oxidizing slag below about 950°C. In fact, although Borowiec refers to a temperature of above about 950°C for the oxidation step, the oxidation step was in fact carried out at a temperature of 1000°C and higher in all the examples except the comparative examples. There is accordingly no overlap with the present invention as claimed in the amended claims and, in fact, Borowiec teaches away from the present invention.

In general, the process according to the present invention is an advancement over Borowiec '420 in that it shows that titania slags wherein an anatase phase stabilizes during oxidation can be oxidized at lower temperatures than known before, and excellent upgrading can still be achieved. The fact that titania slags can be oxidized at such lower temperatures can lead to major savings. Furthermore, titania slags that have been oxidized and reduced according to the present invention can be leached at atmospheric pressure and excellent upgrading is achieved. This also leads to cost savings and in addition less expensive equipment is required. According to Borowiec '420, the oxidized and reduced titania slags, where no anatase phase stabilized, have to be leached at a pressure above atmospheric pressure to upgrade the slags.

Claims 1-6, 8-10 and 15-19 also stand rejected under 35 USC §103(a) as being obvious and therefore unpatentable over Tolley U.S. 4,416,693.

Tolley '693 refers to the recovery of titanium metal values from metal bearing sources containing titanium and iron. In the specification of Tolley '693, there is only reference to ilmenite, rutile, etc. (col. 1, line 24), which are all ores. The examples of Tolley '693 also only

refer to ilmenite ores. Accordingly, Tolley '693 nowhere discloses or suggests that the process can be applied to titania slag as is the case in the present invention.

The differences between ilmenite ore and titania slags, and reasons why processes relating to ilmenite ore are not applicable to titania slag, have been discussed in detail above. The position in respect of the treatment of ilmenite as set out in Tolley '693 is no different from the treatment of ilmenite as discussed above in respect of GB1,225,826, and it has been clearly indicated that a person skilled in the art would not have applied the conditions set out in GB 1,225,826 (and therefore also Tolley '693) to titania slags. In fact, it has been indicated that the prior art in the form of Borowiec '420 teaches away from such an application. Furthermore, Tolley '693 also teaches away from the application of the process on titania slag. Tolley '693 teaches (col. 4, lines 4-9) that oxidation is to take place at a temperature "less than that which is required to form pseudobrookite." As stated above, one of the major differences between ilmenite ore and titania slag is that titania slag includes pseudobrookite and ilmenite ore does not. Slags, and therefore also the slags treated in the present invention, include pseudobrookite (see, e.g., page 10, line 15). The prior art of Borowiec '420 teaches that pseudobrookite is inert towards the action of mineral acids (col. 3, lines 36-38). It is a main feature of Borowiec to modify the pseudobrookite to render it more leachable (see, e.g., page 10, 2nd paragraph). The prior art teaches that the difficulty with leaching of slags is in the fact that pseudobrookite is present. Since Tolley '693 teaches that the formation of pseudobrookite should be avoided, it teaches away from using the process on titania slags that include pseudobrookite.

The claims are also subject to general grounds of rejection under 35 USC §112, 2nd paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter that Applicants claims as their invention.

In response, in addition to the amendments discussed above, claims 1 and 6 are amended to recite --causing-- steps in place of the "allowing" steps found objectionable by the Examiner, and the phrase reciting "a substantial portion" is deleted from the claims. Also, claims 1, 2, 6, and 15 are amended to recite the temperature rang as --to below about-- rater than "and above but below about," as suggested by the Examiner. Claim 4 is amended to correct the noted ungrammatical phrase. Claims 12 and 13 are amended for proper antecedent basis. Claims 5, 14,

ad 18 are cancelled, without prejudice. We submit that all of the objections by the Examiner have been fully addressed.

The abstract for this application, which was submitted as part of the preliminary amendment mailed June 15, 2001, has also been amended herein to conform to the amended claims and to the requirements of U.S. practiced. As requested by the Examiner, a copy of the amended abstract is attached to this response on a separate sheet.

Attached also is a marked-up version of the changes being made by the current amendment.

Applicants submit that this application is now in condition to be allowed. Early favorable action is solicited. Please apply any charges or credits to Deposit Account No. 06-1050.

Respectfully submitted,

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Version with markings to show changes made

In the specification:

Paragraph beginning at page 12, lines 9-10 has been amended as follows:

--[Preferably less than 90%, more preferably less than 95% and most] Most preferably, none of the titanium in the Ti(IV) state is converted to the Ti(III) state during reduction.--

In the claims:

Claims 5, 14 and 18 have been cancelled, without prejudice.

Claims 1, 2, 4, 6, 12, 13 and 15 have been amended as follows:

--1. (Twice Amended) A method of treating titania slag to increase the leachability of impurities from the slag comprising the steps of

sizing the titania slag to a particle size from 75 to 850 μm;

oxidizing the sized slag particles in an oxidizing atmosphere at a temperature from about 700°C [and above but] to below about [950] 900°C for at least 30 minutes [allowing] causing an anatase phase to stabilize in the slag, [allowing] causing the iron present in the slag to concentrate at the exposed surfaces of the slag particles, [allowing] causing a major portion of the iron in the Fe(II) state to convert to the Fe(III) state, and [allowing] causing the titanium in the Ti(III) state to be converted to the Ti(IV) state; and

reducing the oxidized slag in a reducing atmosphere from about 700°C to about 950°C for at least 5 minutes to convert a major portion of the iron in the Fe(III) state to the Fe(II) state [and without converting a substantial portion of the titanium in the Ti(IV) state to the Ti(III) state].--

--2. (Amended) The method of claim 1 wherein the oxidation is carried out at a temperature from about 750°C [and above but] to below about 900°C.--

--4. (Twice Amended) The method of any one of the claims 1 to 3 wherein more than 90% of the iron in the Fe(II) state is converted to the Fe(III) state during [oxidized] oxidizing of the slag.--

--6. (Twice Amended) A method of beneficiating titania slag to increase the TiO_2 content thereof to at least 90% by weight comprising the steps of:

sizing the titania slag to a particle size from 75 to 850 μm;

oxidizing the sized slag particles in an oxidizing atmosphere at a temperature from about 700°C [and above but] to below about [950] 900°C for at least 30 minutes [allowing] causing an anatase phase to stabilize in the slag, [allowing] causing the iron present in the slag to concentrate at the exposed surfaces of the slag particles, [allowing] causing a major portion of the iron in the Fe(II) state to convert to the Fe(III) state, and [allowing] causing the titanium in the Ti(III) state to be converted to the TI(IV) state;

reducing the oxidized slag in a reducing atmosphere from about 700°C to about 950°C for at least 5 minutes to convert a major portion of the iron in the Fe(III) state to the Fe(II) state [and without converting a substantial portion of the titanium in the Ti(IV) state to the Ti(III) state]; and

leaching the reduced slag with acid to obtain a beneficiated slag product with an increased TiO_2 content and leach liquor containing the leached impurities.--

--12. (Amended) The method of claim 6 which includes a step of calcining the [treated] beneficiated slag product.--

--13. (Amended) The method of claim 12 wherein the [treated] beneficiated slag product is washed and dried to remove volatile by products prior to the calcining step.--

--15. (Twice Amended) The method of any one of claims 6 to 13 wherein the oxidation is carried out at a temperature from about 750°C [and above but] to below about 900°C.--

In the abstract:

--This invention relates to a method of treating titania slag to increase the leachability of impurities from the slag [comprising] consisting of the steps of sizing the titania slag to a particle size from 75 to 850 μm; [oxidising] oxidizing the sized slag particles at a temperature from about 700°C [and above but] to below about [950] 900°C [allowing] causing the iron present in the slag to concentrate at the exposed surfaces of the slag particles and/or [allowing] causing an anatase phase to [stabilise] stabilize in the slag, [allowing] causing a major portion of the iron in the Fe(II) state to convert to the Fe(III) state, and [allowing] causing the titanium in the Ti(III)

state to be converted to the Ti(IV) state; and reducing the [oxidised] <u>oxidized</u> slag in a reducing atmosphere from about 700°C to about 950°C to convert a major portion of the iron in the Fe(III) state to the Fe(II) state [and without converting a substantial portion of the titanium in the Ti(IV) state to the Ti(III) state]. The invention also relates to a method of [benificiating] <u>beneficiating</u> titania slag to increase the TiO_2 content thereof wherein the above treated slag is leached with acid.--